over this great plateau presents them as direct obstructions to the eastward movement of storms, and their influences on the latter are very marked. Indeed the most interesting study in American meteorology is that of the modifications produced by the great mountain plateau of the west, or the disturbances passing over it. The sub-area of the plains is that in which some of the most remarkable phenomena of storms are observed. The valleys of the Mississippi, Missouri, and Ohio, and the basins of the lakes and Gulf of Mexico are the theatres of tremendous storm movements, and are consequently the favourite areas for observation chosen by American meteorologists. Within them are experienced nearly every type of storm that traverses the Atlantic toward Europe. Unlike the sub-area of the mountains to the westward, that of the plains is favoured with an abundant rainfall which renders the great expanse fertile in nearly all its sections. The growths of the tropics flourish in the south, and productiveness marks its various climatic zones until the vast pine forests of the north define the agricultural limits. The contrast between the two sub-areas is extraordinary, yet their widely different conditions are easily accounted for when their respective meteorological aspects are studied. The Gulf of Mexico, with its accumulation of tropical waters, plays a very important part in creating the prevailing weather conditions of the sub-area of the plains. From it flows a continuous current of warm humid air, which supplies moisture and energy to the storms that descend from the regions of the north-west into the great river valleys. It is the cradle of the equatorial current that sweeps across the ocean far into the Arctic seas, carrying warmth and verdure to latitudes in Europe far north of the general habitable limit on the American continent. But it is unnecessary to do more than refer to so familiar a region in describing briefly the natural subdivisions of the field of observation.

For the Atlantic, like the Pacific, we have the dividing line of the equatorial current of the Gulf Stream. North and west of that line the surface temperature is low, south and east of it very uniform, and along it high. Air in motion over these surfaces is consequently affected by rapid variations of temperature, which affect in turn the energy of the disturbances traversing the atmospheric volume.

A very marked effect of this kind is produced when storms leave the Nova Scotia coast, and at once commence to pass over the equatorial and Polar counter currents. The pressure falls rapidly, and great gales are induced, but the storm seems to be held for several hours over the region between Nova Scotia and Newfoundland, as if controlled by forces which it strove to overcome. When fairly past Cape Race the movement of the storm is no longer interrupted by the influences of the currents, and makes a very uniform progress towards Europe. When cyclonic storms reach the Florida or Carolina coasts from the Gulf of Mexico their energy seems to be increased when passing over the Gulf Stream, but their courses are not altered very much by the influence of that current. This is probably due to its narrowness when passing along the coast to latitude 35°. Eastward of the Gulf Stream, and over the oceanic region of uniform surface temperatures the energy of the storms decreases somewhat, and the areas of their depressions increase. But on approaching the west coasts of Europe the storms again resume their forces and deposit heavy rains. Europe, like America, is divisible into two sub-areas, one of mountains and the other of plains. The eastern limit of the former is that of a line following the Scandinavian Mountains toward the Alpine development into Saxony, thence following the Carpathian mountain outline, and passing southward over Bulgaria and the Balkans to the Syrian mountains. The irregularity of such a dividing line is very apparent, but we may assume that given to be correct enough for our purposes. In crossing the Scandinavian Mountains, Atlantic storms invariably deposit a great rainfall over Norway and pass into the Gulf of Bothnia and Eastern Russia with a reduced precipitation. When on the great Muscovite plains the storms again increase in area, just as they do in the valley of the Mississippi after crossing the Rocky Mountains in Montana; the break in the dividing-line between the sub-areas of mountain and plain in Europe represented by the Baltic and the low lands of Northern Germany, forms a storm gateway to the interior plains, which is frequently passed by Atlantic disturbances. The mountain systems of Switzerland, Italy, and the Balkan peninsula, perform important parts in modifying the conditions during storm movements in Northern Europe, and have each their peculiar local influences on the weather. If these mountains did not form barriers between the regions of great evaporation with their humid winds from the south, and those of Northern and Central Europe, a parallel between the meteorological phenomena of the Mississippi Valley and those of Eastern and Southern Russia in Europe could be drawn very easily. Having now roughly sketched the field of observation at present available, and suggested here and there a few points worthy of special consideration, I will endeavour in the next article to explain how storms move over the several sub-areas, and the changes they undergo in each.

JEROME J. COLLINS

(*To be continued.*)

NEWCOMB'S ASTRONOMY

Popular Astronomy. By Simon Newcomb, LL.D., Professor U.S. Naval Observatory. (London: Macmillan and Co., 1878.)

A WORK on popular astronomy by an author so distinguished in the higher branches of the science as Prof. Newcomb, will be welcomed with more than ordinary interest. The main object of the present volume is to present the general reader with a condensed view of the history, methods, and results of astronomical research, especially in fields of most popular and philosophical nature at this epoch, in such language as to be intelligible without mathematical study; it has not been designed to instruct either the professional investigator or the special student of astronomy.

In his first chapter the author briefly treats of the phenomena of diurnal motion, the motion of the sun amongst the stars, the precession of the equinoxes, of the moon's motion, and of eclipses of the sun and moon, concluding with some account of the calendar. In his second and third chapters the true or Copernican system of the universe is described, the obliquity of the ecliptic, the seasons, &c., according to this system, the Keplerian laws of planetary motion, and progress from Kepler to Newton. The latter of these chapters is devoted to Newton's discovery of universal gravitation and consequences flowing from it; the gravitation of small masses, the figure and density of the earth, the tides, the inequalities in the motions of the planets produced by their mutual attraction, and the relation of the planets to the stars. The three chapters form the first part of the work, or "the history of the world historically developed."

The second part is devoted to practical astronomy, the telescope and the successive improvements and modifications introduced in its construction and application down to the present day. The cumbrous yet elaborate form in which an instrument, powerful for its time, was used in the middle of the seventeenth century, is well illustrated by an engraving of the great telescope used by Blanchini in the observations whereby he attempted to determine the time of rotation of the planet Venus upon its axis, one of the instruments constructed by the celebrated Campani, mounted in the grounds of the Barbarini Palace at Rome, and extracted from the historical work "Hesperi et Phosphori Nova Phenomena." As specimens of modern optical and mechanical achievement, we have illustrations and descriptions of the great reflectors of the Earl of Rosse and Mr. Lassell, of the Melbourne instrument and the new reflector in the grounds of the Observatory of Paris. The great refractor of the Naval Observatory of Washington is represented in the frontispiece—a reduction from the picture forming one of the series in the last volume of Washington Astronomical Observations; the instrument with which observations have been made that have afforded us the first really satisfactory knowledge of the elements of the orbits of the four satellites of Uranus and the satellite of Neptune, and what is of still greater interest, the instrument with which Prof. Asaph Hall has brought to light the two minute satellites of Mars, a discovery justly characterised by Leverrier as one of "the most important observations of modern astronomy." The application of the telescope to celestial measurement, the meridian circle and its use, the determinations of time and of terrestrial longitudes, are also considered, and the author proceeds to treat of parallax in general, and in particular of the investigation of the solar parallax, through the intervention of the parallax of one of the planets Venus and Mars when nearest to the earth. Prof. Newcomb supplies a sketch of progress and results in this direction from the first application of the method to the planet Mars, on occasion of the French expedition in 1671, when Richer was sent out to the colony at Cayenne, in South America, to secure observations of Mars, while corresponding observations were made at the Observatory of Paris, from the discussion of which observations Cassini made what is usually given as the first reliable approximation to the amount of the sun's parallax, the resulting value being $9''\cdot5$. The author, however, remarks upon the determination made by Huyghens at the end of his "Systema Saturnium," as the best of the seventeenth century, the reason, as he states, of its being the best being that it was not founded on any attempt to measure the parallax itself, which was then really incapable of measurement, but on the probable magnitude of the earth as a planet. The idea of Huyghens was that the earth, being a planet, its magnitude would probably be somewhere near that of the average of the two planets on each side of it, viz., Venus and Mars. So, taking the mean of the diameters of Venus and Mars, and supposing this to represent the diameter of the earth, he found the angle which the semi-diameter of the supposed earth would subtend from the sun, which would be the solar parallax. By a fortunate accident, Prof. Newcomb remarks, Huyghens's estimate was nearer the truth than any determinations made previous to the transit of Venus in 1769, "his result for the distance of the sun being 25,086 semi-diameters of the earth, or 99,000,000 of miles." But it is to be noted that if Huyghens had used the correct measures of Venus and Mars, he would have been further from the truth; his telescopes showing the planets with diameters in excess of the true ones, "he just hit the diameter of the earth, and reached the true solution of the problem." This attempt of Huyghens to ascertain the amount of solar parallax, is not often mentioned in our astronomical treatises.

The section bearing upon investigations of the solar parallax from transits of Venus, though brief, contains some interesting facts; the proceedings of the American expeditions for the observation of the transit of 1874, are particularly noticed. It appears that the stations finally occupied by the observers sent out from the United States were, Wladiwostok, in Siberia, Pekin and Nagasaki, Japan, in the northern hemisphere, and Kerguelen Island, Hobart Town, and Campbelltown, Tasmania, Queenstown, N.Z., and Chatham Island in the opposite one. The American astronomers relied chiefly upon the photographic method of observing the transit, as possessing obvious advantages over the old method of noting the contacts, and the author describes and illustrates by a diagram, how by the use of a telescope of great length—nearly forty feet—difficulties in the measurement of the photographs were sought to be obviated by the French and American parties, as well as by Lord Lindsay. With regard to the success attending the American expeditions, Prof. Newcomb, (who it may be remarked was one of the principal agents in the arrangement of their equipment and plans of observation) states that the full number of photographs expected was not obtained at any station—but that the result taking the stations collectively, was about half this number; the British, French, and Russian expeditions were about equally successful, while the most fortunate, as regards weather, were the German parties who were successful at all six of their stations. He adverts to the amount of labour attending the investigation and measurement of the photographs, and with respect to the time when a final result may be expected to be worked out from the observations of the transit of 1874, having in view the comparison of the whole to ascertain how consistent they are with each other, adds: "this cannot be done for several years," yet that upon the question whether it is worth while to send out parties to observe the transit of 1882, which must soon be a subject of discussion among astronomers, the answer must depend very largely on the success of the efforts made in 1874. We should be inclined to hope, however, that the results of Mr. Gill's expedition to Ascension, with Lord Lindsay's heliometer, for observations of the recent close opposition of the planet Mars, may very materially facilitate a decision upon this point. If, as many practical astronomers have anticipated, an equally reliable determination of the sun's distance can be obtained from measuring heliometrically the diurnal parallax of Mars at those oppositions when he approaches nearest to the earth, as from the observation by the combined exertion of civilised nations, of a transit of Venus, then it may be reasonably expected that a method admitting of comparatively such frequent repetition, and involving also so small an outlay, not only as to cost, but labour of preparation, must be preferred by astronomers generally, thus facilitating a proper conclusion with respect to expensive preparation for observing the transit in 1882.

After briefly describing other methods of approximating to the amount of solar parallax which have been applied, including M. Cornu's determination from measurement of the velocity of light and Leverrier's results from the planetary theories, and the method first suggested by Prof. Galle, by measuring the parallax of the small planets, a method which, in a modified form, was applied with so much success on the occasion of the near opposition of Juno in 1874, Prof. Newcomb sums up results by stating that "from the general accordance of the various methods described, it would appear that the solar parallax must lie between pretty narrow limits, probably between 8″·82 and 8″·86, and that the distance of the sun in miles probably lies between the limits 92,200,000 and 92,700,000." This, however, it must be observed, appears to have been written before any of the results of the transit of Venus were published, as the author expresses the hope that after their discussion the uncertainty may be brought within yet narrower limits.

The chapter concludes with an outline of the various investigations of stellar parallax, the most trustworthy values being collected in a tabular form at the end of the volume, and the same has been done as regards successive determinations of the mean parallax of the sun. By thus avoiding the introduction of any considerable amount of numerical detail into the text, the volume is rendered much more readable; indeed, in this respect we may remark, once for all, that the author's arrangement leaves nothing to be desired.

The second part of the work further includes chapters on the motion of light as measured by celestial observations, and experimentally on the methods devised or practised by MM. Foucault, Fizeau, and Cornu; the application of the revolving wheel is explained. A brief outline of the principles of spectral analysis as applied to the heavenly bodies is presented in conclusion. With reference to doubts which have found expression at times as to the degree of certainty attaching to some of the inferences drawn from spectroscopic observation, and remarking that the dark and bright lines in the spectrum are "the letters of the open book which we are to interpret so as to learn what they tell us of the body from which the light came, or the vapours through which it passed," the author introduces the question, How do we know but that the lines we observe may be produced by other substances besides those which we find to produce them in our laboratories? May not the same lines be produced by different substances? The answer to this question can only be founded upon an appeal to probabilities. "The evidence in this case is much the same as that by which, recognising the picture of a friend, we conclude that it is not the picture of any one else. For anything we can prove to the contrary, another person might have exactly the same features, and might, therefore, make the very same picture. But, as a matter of fact, we know that practically no two men whom we have ever seen do look exactly alike, and it is extremely improbable that they ever would look so. The case is the same in spectrum analysis. Among the great number of substances which have been examined with the spectroscope, no two give the same lines. It is therefore extremely improbable that a given system of bright lines could be produced by more than one substance." Nevertheless, it is remarked that the evidence of the spectroscope is not necessarily conclusive in all cases. In the case of a single line only of a substance being found in the spectrum of a star or nebula, it would hardly be safe to infer from this alone that the line was really produced by the known substance, In such doubtful instances collateral evidence must be allowed its weight, and conclusions must be drawn with care and discrimination, in accordance with the probabilities of each special case.

The third part of the work is devoted to a description of the sun and planets, the comets and meteors. The author has had the advantage of outlines of the views of several distinguished students of the physical constitution of the sun, which he presents in their own words. These include notes by Father Secchi, M. Faye, and Prof. Young. On the subject of intra-mercurial planets he remarks upon the fact of suspicious objects thus far having been seen only by amateur observers, and escaping the skilled astronomers who have occupied themselves in watching the sun's disc, and appears to consider that this circumstance places their real existence beyond moral probability. He favours the idea that if the motion of the perihelion of Mercury be due to the action of a group of planets, they are each so small as to be invisible in transits across the sun, and during total eclipses, and yet being so large in the aggregate, their number must be counted by thousands, and if seen at all they would appear only as a cloud-like mass. The zodiacal light offers this aspect, and the question arises whether the matter which reflects this light can be that which affects the motion of Mercury, and Prof. Newcomb is rather in favour of this explanation, though, he adds, "a great deal of research—more, in fact, than is likely to be applied to the subject during the present generation —will be required before the question can be settled."

The fourth part treats of the stellar universe, the second chapter on the structure of the heavens meriting especial attention. Space will not allow of our entering in detail upon the contents of this last portion of the volume; it concludes with an expression of the author's ideas relative to the much-discussed question of the Plurality of Worlds. This last part will probably possess greater interest for many than the rest of the work, though necessarily entering upon subjects not yet removed from the region of speculation. Prof. Newcomb, however, does not mix up what is merely speculative with well-established conclusions in such way as to mislead his readers who may be entering upon the study of astronomy—a failing of too many works issued at the present day.

As affording a thoroughly reliable foundation for more advanced reading, Prof. Newcomb's "Popular Astronomy" is deserving of strong recommendation.

J. R. HIND

SLATE AND SLATE QUARRYING

A Treatise on Slate and Slate Quarrying, Scientific, Practical, and Commercial. By D. C. Davies, F.G.S. (London: Crosby Lockwood and Co., 1878.)

AMONGST the manufacturing industries which, during the last hundred years, have expanded into large proportions is the production of roofing slate. Nor is it difficult to account for this expansion. Building operations have in this period progressed both over town and country, both in the Old and New World with extraordinary rapidity, while canals and railroads have facilitated the transport of the roofing slates from their mountain sources to all parts of the land, and ships traverse the seas with cargoes of the same material to various countries. Before the introduction of canals and railways into the British Isles, the slates of Wales, Cumberland, Scotland, and Ireland were restricted to the immediate neighbourhood of the quarries from which they were extracted, and buildings in various parts of the country far removed from these quarries, were supplied with roofing materials from other sources. In many districts tiles of burnt clay formed the only available material, while in others, flag-stones and tile-stones from the Carboniferous, Triassic, or Oolitic formations were extensively used. In the eastern and central districts of England the tile-stones of Stonesfield, near Oxford, those of the Cotteswold Hills, and of Collyweston formed an available source of supply; and it must be admitted that their greyish colour and general appearance harmonise well with the prevalent Gothic or Tudor styles of architecture of those districts. To such an extent is this admitted that these tilestones (erroneously called "slates") are still largely used in the counties of Northampton, Oxford, and Gloucester, even when the Welsh slate might be obtained at an equal or less cost, and, owing to their heaviness, the high-pitched roofs, which are so ornamental, and add so much to the appearance of buildings, became a necessity. Nevertheless, the Oolitic tilestones are inferior in strength, lightness, and durability to the latter material, and are only used where æsthetic considerations prevail over those of economy.

In no country of equal extent has the art of slate-quarrying reached such proportions as in the British Isles, and especially amongst the mountains of North Wales, which is its principal seat; and considering the magnitude of the works carried on, the large number of persons employed, and the enormous sums made and lost in this branch of trade, it is somewhat strange that no work specially devoted to the subject of slate quarrying has appeared up to this time. We therefore welcome Mr. Davies' little treatise, in which will be found a large amount of interesting and valuable information regarding the slate industries of North Wales and other districts, gathered from much experience and observation, and placed before the public in a very readable form.

Mr. Davies, being a geologist, treats his subject geologically, recounting the various formations of North Wales in which the various "veins" or beds of the best slates are to be found; and giving numerous details, often illustrated by sketches of the stratigraphical phenomena which are encountered in the quarries. Few people have any idea of the physical impediments which occur in such places. What with dykes, veins, slips, the disappearance of cleavage planes, the local change in texture and composition of the slate itself, and other disturbances and "troubles," it is only a comparatively small proportion of the entire slate-bed which can, even in the best quarries, be converted into marketable slates, of the larger sizes and qualities, known as "Princesses," "Duchesses," and "Countesses." Hence it is, that while a band of slate-rock, in a favourable position for carriage, and comparatively free from such impediments to its useful application, is a source of profit, another band, which is not so free from these accidents of stratification, remains a profitless, or ruinous possession.

Commencing with the oldest formation of North Wales, the Lower Cambrian of Prof. Sedgwick, Mr. Davies describes the eminently successful quarries opened in this formation in the Pass of Llanberris, which have proved a source of untold wealth to their fortunate owners. The slates from this formation are generally purple or greenish —locally becoming greyish—and are amongst the smoothest and strongest in Wales. The succeeding formations of the Upper Cambrian and Lower Silurian are also productive of slates—generally of bluish and dark tints—and are worked over the central portions of the mountain region. The value of such beds of slate depends chiefly upon the uniformity and fineness of the grain of the slate, and the facility with which the rock splits along the planes of cleavage—which, as all geologists are aware, are independent of those of bedding. In reference to the origin of the cleavage structure, we are glad to find that the author adopts the "mechanical theory," which ascribes the structure to the enormous lateral pressure to which the rocks have been subjected when undergoing contortion; but in enumerating the observers who have contributed towards our knowledge on this subject, he has omitted the name of the late Mr. Daniel Sharpe, whose remarkable papers published in the *Journal* of the Geological Society (vols. iii. and v.), clearly established the relationship between cleavage and pressure, and the structural alterations which have been brought about within the mass of the slate-rock itself, as subsequently confirmed and illustrated by Mr. Sorby, after the microscopical examination of thin sections.

The author's notices of slate-production in districts other than those of North Wales are scanty, and consist of extracts from other works. His book is, therefore, mainly valuable for the information it affords regarding the position, structure, and mode of working the bands of slate in the lower palæozoic formations of North Wales; and as such it will be found a useful guide-book.